

Emissions - Cumulative Summary from all Activities

Exhaust Criteria Pollutants

Borings for Approach Channel Cofferdam

(Oct 2010 through Jan 2011)

Period of Operation (months)

4

Worker Commute Emissions

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Pounds		187.20	17,798.00	19.01	1.54	0.92	0.18	20.35
Tons		0.094	8.90	0.010	0.00077	0.00046	0.000090	0.010

Construction Equipment Exhaust

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Average annual tons		0.14		0.58	0.016	0.016		0.042
Total annual average tons		0.23		0.59	0.017	0.016		0.052

Control Structure

(Jan 2011 through July 2014)

Total Period of Operation (months)

42

Worker Commute Emissions (Excavation, Concrete Placement, Gate Installation)

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Total Pounds		14,332.50	1,362,690.00	1,455.30	117.60	70.41	14.10	1,558.20
Total Tons		7.17	681.35	0.73	0.059	0.035	0.0071	0.78
Average annual pounds		4,095.00	389,340.00	415.80	33.60	20.12	4.03	445.20
Average annual tons		2.05	194.67	0.21	0.017	0.010	0.0020	0.22

Construction Equipment Exhaust

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Excavation - Average annual tons	(Jan 2011 - Sept 2011; 9 months)	15.16		13.09	0.49	0.49		1.95
Concrete Placement - Average annual tons	(July 2011 - July 2013; 24 months)	5.59		4.20	0.13	0.13		0.69
Gate Installation - Average annual tons	(Dec 2013 - July 2014; 9 months)	1.23		0.84	0.023	0.023		0.14
Maximum Annual Cumulative - Avg. annual tons	(During the year 2011: Excavation + 6 months concrete)	17.96		15.19	0.555	0.555		2.30

On-Site Haul Truck

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Average annual tons (2011)		0.35		53.25	0.43	0.025	0.00042	0.071

Off-Site Haul Truck

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Average annual tons		0.67	280.40	2.66	0.10	0.088	0.0020	0.18
Maximum Annual Cumulative - Avg. annual tons	(During the year 2011)	21.02		18.49	0.70	0.68		2.77

Chute and Stilling Basin

(late 2013 through 2016)

Period of Operation (months)

36

Worker Commute Emissions

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Total Pounds		12,285.00	1,168,020.00	1,247.40	100.80	60.35	12.08	1,335.60
Total Tons		6.14	584.01	0.62	0.050	0.030	0.0060	0.67
Average annual pounds		4,095.00	389,340.00	415.80	33.60	20.12	4.03	445.20
Average annual tons		2.05	194.67	0.21	0.017	0.010	0.0020	0.22

Construction Equipment Exhaust

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Average annual tons		10.42		7.77	0.25	0.25		1.29

Off-Site Haul Truck

		Unmitigated						
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Average annual tons		0.79	332.44	3.16	0.12	0.10	0.0024	0.21
Total Annual Average Emissions		13.26		11.14	0.39	0.36		1.72

Maximum Annual Cumulative for Control Structure Gate Installation plus Chute and Stilling Basin - Avg. annual tons (During the year 2014: Chute and Stilling Basin annual average + 7 months of Gate Installation)

16.07		13.65	0.48	0.44		2.10
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Mitigated

(No mitigations)

	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
	187.20	17,798.00	19.01	1.54	0.92	0.18	20.35
	0.094	8.90	0.010	0.00077	0.00046	0.000090	0.010

Mitigated (Enhanced Control Practices)

20% reduction in NO_x; 45% reduction in PM₁₀

	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
	0.14		0.46	0.0088	0.0088		0.042
	0.23		0.47	0.010	0.0093		0.052

Months of operation during Control Structure construction:

Excavation (months)	9	Gate installation (months)	9
Aggregate and concrete	24		

Mitigated

(No mitigations)

	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
	14,332.50	1,362,690.00	1,455.30	117.60	70.41	14.10	1,558.20
	7.17	681.35	0.73	0.059	0.035	0.0071	0.78
	4,095.00	389,340.00	415.80	33.60	20.12	4.03	445.20
	2.05	194.67	0.21	0.017	0.010	0.0020	0.22

Mitigated (Enhanced Control Practices)

20% reduction in NO_x; 45% reduction in PM₁₀

	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
	15.16		10.47	0.27	0.27		1.95
	5.59		3.36	0.072	0.072		0.69
	1.23		0.67	0.013	0.013		0.14
	17.96		12.15	0.305	0.305		2.30

Mitigated (Enhanced Control Practices)

	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
	0.35		53.25	0.34	0.014	0.00042	0.071

Mitigated (No mitigations)

	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
	0.67	280.40	2.66	0.10	0.088	0.0020	0.18
	21.02		15.36	0.44	0.42		2.77

Appendix A-2: Exhaust Emissions -Construction Equipment

Emissions - Construction Equipment Exhaust

Note: No CO₂ Calculations in this worksheet

Equipment

Type	Number	Hours per day	Days per week	Months	Hours per week	Hours per Project	Calculated 8-hour days per Project
CONTROL STRUCTURE - Concrete Placement and Batch Plant (24 months) July 2011 through July 2013							
Semi-trailer truck	20	4	5	12	400	19,200	2,400
Belly dump truck	8	4	3	16	96	6,144	768
Tanker trucks	2	4	3	16	24	1,536	192
Chiller	1	10	5	12	50	2,400	300
Stationary Cranes - electric	2	8	5	12	80	3,840	480
Forklifts	2	4	5	12	40	1,920	240
Man lift/scissor lift - electric	2	8	5	12	80	3,840	480
Water truck	1	4	5	12	20	960	120
Street sweeper	1	8	1	12	8	384	48
Jackhammers	2	8	1	12	16	768	96
Cement mixers (transit)	0	4	5	12	0	0	0
Front end loaders	2	8	5	8	80	2,560	320
Flatbed delivery truck	1		5				

Control Structure Concrete Placement Annual Average Emissions							
Control Structure Concrete Placement 2011 Annual Emissions (6 months)							
Control Structure Concrete Placement 2012 Annual Emissions (12 months)							
Control Structure Concrete Placement 2013 Annual Emissions (6 months)							

CONTROL STRUCTURE - Excavation (9 months) January 2011 through September 2011							
"Super" dump trucks	5	8	5	6	200	4,800	600
Water trucks	1	4	5	6	20	480	60
Fuel truck	1	2	5	8	10	320	40
Maintenance truck	4	4	5	8	80	2,560	320
Pickup trucks	10	4	5	8	200	6,400	800
Drills for grouting - electric	6	8	5	9	240	8,640	1,080
Rock drills for setting charges	NE	NE	NE	NE	NE	7,353	919
Front end loaders	2	8	5	8	80	2,560	320
Dozers with rippers	2	8	5	8	80	2,560	320
Backhoes	4	8	5	8	160	5,120	640
Graders	2	8	5	8	80	2,560	320
Scrapers	3	8	5	3	120	1,440	180
Excavators	2	8	5	5	80	1,600	200
Compactor sheep foot	2	8	5	3	80	960	120

NE = Not Estimated

Control Structure Excavation Annual Average Emissions (All in 2011)							
Total Control Structure 2011 Emissions (Excavation plus Concrete Placement)							

CONTROL STRUCTURE - Gate Installation (9 months) December 2013 through July 2014							
Track driven cranes	2	8	5	5	80	1,600	200
Flat bed trucks							

Control Structure Gate Installation Annual Average Emissions (Assume in 2014)							
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CHUTE AND STILLING BASIN - Concrete Placement and Batch Plant (36 months) Late 2013 through 2016							
Semi-trailer truck	20	4	5	36	400	57,600	7,200
Belly dump truck	8	4	3	36	96	13,824	1,728
Tanker trucks	2	4	3	36	24	3,456	432
Chiller	1	10	5	36	50	7,200	900
Stationary Cranes - electric	2	8	5	36	80	11,520	1,440
Forklifts	2	4	5	36	40	5,760	720
Man lift/scissor lift - electric	2	8	5	36	80	11,520	1,440
Water truck	1	4	5	36	20	2,880	360
Street sweeper	1	8	1	36	8	1,152	144
Jackhammers	2	8	1	36	16	2,304	288
Cement mixers (transit)	0	4	5	36	0	0	0
Front end loaders	2	8	5	36	80	11,520	1,440
Flatbed delivery truck	1		5				

CHUTE AND STILLING BASIN - Foundation Preparation/Backfill (36 months) Late 2013 through 2016							
Fuel truck	1	2	5	36	10	1,440	180
Water truck	1	4	5	36	20	2,880	360
Front end loader	1	4	5	36	20	2,880	360
Pickup trucks	5	4	5	36	100	14,400	1,800
Track driven cranes	2	4	5	24	40	3,840	480
Drills for grouting - electric	6	8	5	24	240	23,040	2,880
Portable cement mixers	2	4	5	12	40	1,920	240

Chute and Stilling Basin Annual Average Emissions (Assume emissions in 2014, 2015, 2016)							
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Unmitigated Emissions (pounds)			
ROG	CO	NO _x	PM ₁₀

Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
624	5,133	3,852	117
0	0	0	0
190	1,608	1,097	31.2
0	0	0	0
53	266	324	19
100	821	616	19
200	1,643	1,233	37
0	0	0	0
208	1,715	1,286	38

Off-site Haul Truck calculations

Unmitigated Emissions (tons)			
ROG	CO	NO _x	PM ₁₀

Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
0.31	2.57	1.93	0.059
0	0	0	0
0.095	0.80	0.55	0.016
0	0	0	0
0.03	0.13	0.16	0.009
0.050	0.41	0.31	0.0094
0.10	0.82	0.62	0.019
0.00	0.00	0.00	0.00
0.10	0.86	0.64	0.019

Unmitigated Estimated Annual Emissions (tons)			
ROG	CO	NO _x	PM ₁₀

Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
0.31	2.57	1.93	0.059
0	0	0	0
0.095	0.804	0.548	0.016
0	0	0	0
0.027	0.133	0.16	0.009
0.050	0.411	0.31	0.0094
0.100	0.821	0.62	0.019
0.000	0.00	0.00	0.00
0.104	0.858	0.643	0.019

Off-site Haul Truck calculations

	0.69	5.59	4.20	0.13
2011	0.34	2.80	2.10	0.07
2012	0.69	5.59	4.20	0.13
2013	0.34	2.80	2.10	0.07

On-site Haul Truck calculations			
On-site Haul Truck calculations			
On-site Haul Truck calculations			
27	133	162	9
18	89	108	6
142	709	863	50
54	509	59	4.3
0	0	0	0
888	5,545	8,447	431
208	1,715	1,286	38
464	3,824	2,867	86
416	3,430	2,573	77
563	4,794	3,270	90
655	5,573	3,802	104
368	3,128	2,134	58
103	881	601	17

On-site Haul Truck calculations			
On-site Haul Truck calculations			
On-site Haul Truck calculations			
0.013	0.07	0.08	0.005
0.009	0.04	0.05	0.0031
0.07	0.35	0.43	0.025
0.027	0.25	0.029	0.0022
0.00	0.00	0.00	0.000
0.44	2.77	4.22	0.216
0.10	0.86	0.64	0.019
0.23	1.91	1.43	0.043
0.21	1.72	1.29	0.038
0.28	2.40	1.64	0.045
0.33	2.79	1.90	0.052
0.18	1.56	1.07	0.029
0.052	0.44	0.30	0.0084

Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
0.013	0.07	0.08	0.005
0.009	0.04	0.05	0.003
0.07	0.35	0.43	0.025
0.027	0.25	0.029	0.0022
0.00	0.00	0.00	0.000
0.44	2.77	4.22	0.216
0.10	0.86	0.64	0.019
0.23	1.91	1.43	0.043
0.21	1.72	1.29	0.038
0.28	2.40	1.64	0.045
0.33	2.79	1.90	0.052
0.18	1.56	1.07	0.029
0.052	0.44	0.30	0.0084

2011	1.95	15.16	13.09	0.49
2011	2.30	17.96	15.19	0.55

288	2,454	1,674	46
Off-site Haul Truck calculations			

0.144	1.23	0.84	0.0230
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0.144	1.227	0.837	0.023
Off-site Haul Truck calculations			

0.144	1.227	0.837	0.023
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Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
192	957	1,165	67
1,872	15,399	11,556	351
0	0	0	0
569	4,824	3,290	94
0	0	0	0
160	798	971	56
300	2,464	1,849	56
599	4,928	3,698	112
0	0	0	0
936	7,718	5,789	173

Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
0.096	0.48	0.58	0.0337
0.936	7.70	5.78	0.1755
0	0	0	0
0.284	2.41	1.65	0.0468
0	0	0	0
0.080	0.40	0.49	0.0281
0.150	1.23	0.92	0.0281
0.300	2.46	1.85	0.0562
0.000	0.00	0.00	0.0000
0.468	3.86	2.89	0.0864

Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
0.03	0.16	0.19	0.011
0.31	2.57	1.93	0.059
0	0	0	0
0.095	0.804	0.548	0.016
0	0	0	0
0.03	0.13	0.16	0.009
0.050	0.411	0.31	0.0094
0.10	0.82	0.62	0.019
0.00	0.00	0.00	0.00
0.16	1.29	0.96	0.029

Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
Off-site Haul Truck calculations			
0.013	0.066	0.081	0.005
0.027	0.133	0.162	0.009
0.039	0.322	0.241	0.0072
0.020	0.191	0.022	0.002
0.173	1.472	1.004	0.028
0.000	0.000	0.000	0.00
0.250	2.053	1.541	0.047

BORINGS FOR APPROACH CHANNEL COFFERDAM (4 months)										Late 2010 - Early 2011													
Diesel & Hydraulic drill rig	1	10	5	4		50	800	100		97	603	919	47		0.048	0.30	0.46	0.0235		0.048	0.30	0.46	0.023
Flat bed trucks	2	4	5	4						Off-site Haul Truck calculations										Off-site Haul Truck calculations			

Borings for Approach Channel Annual Average Emissions (Assume in 2010)																				0.048	0.30	0.46	0.023
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TOTAL EMISSIONS	12,076	95,928	75,625	2,576	6.0	48.0	37.8	1.3
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Construction Equipment Emission Rates (pounds per day) from Reclamation 2007

Equipment Type	ROG	CO	NO _x	PM ₁₀
Bore/Drill Rigs				
2009	2.38	20.21	16.41	0.38
2010-2016	2.26	19.23	15.61	0.36
Paving Equipment				
2009	1.04	8.23	6.78	0.22
2010-2016	1.04	8.52	6.39	0.19
Rollers				
2009	0.86	7.34	5.01	0.14
2010-2016	0.86	7.34	5.01	0.14
Cranes				
2009	1.44	12.27	8.37	0.23
2010-2016	1.44	12.27	8.37	0.23
Crawler Tractors				
2009	1.45	11.55	9.5	0.31
2010-2016	1.45	11.95	8.96	0.27
Crushing/Proc Equipment				
2009	2.12	16.86	13.88	0.45
2010-2016	2.12	17.45	13.09	0.4
Rough Terrain Forklifts				
2009	0.79	6.7	4.57	0.13
2010-2016	0.79	6.7	4.57	0.13
Rubber Tired Dozers				
2009	3.66	29.13	23.97	0.78
2010-2016	3.66	30.14	22.61	0.68
Rubber Tired Loaders				
2009	1.35	11.52	7.86	0.22
2010-2016	1.35	11.52	7.86	0.22
Excavators				
2009	1.84	15.64	10.67	0.29
2010-2016	1.84	15.64	10.67	0.29
Graders				
2009	1.76	14.98	10.22	0.28
2010-2016	1.76	14.98	10.22	0.28
Off-Highway Tractors/Compactors				
2009	1.84	14.65	12.05	0.39
2010-2016	1.84	15.16	11.37	0.34
Scrapers				
2009	3.64	30.96	21.12	0.58
2010-2016	3.64	30.96	21.12	0.58
Skid Steer Loaders				
2009	0.56	4.78	3.26	0.09
2010-2016	0.56	4.78	3.26	0.09
Off-Highway Trucks/Water Trucks				
2009	3.6	30.62	20.89	0.58
2010-2016	3.6	30.62	20.89	0.58
Other Construction Equipment				
2009	2.08	16.54	13.61	0.44
2010-2016	2.08	17.11	12.84	0.39
Pavers				
2009	1.37	11.62	7.93	0.22
2010-2016	1.37	11.62	7.93	0.22
Surfacing Equipment				
2009	3.77	29.99	24.68	0.8
2010-2016	3.77	31.03	23.28	0.7
Tractors/Loaders/Backhoes				
2009	0.65	5.18	4.26	0.14
2010-2016	0.65	5.36	4.02	0.12
Trenchers				
2009	1.00	8.53	5.82	0.16
2010-2016	1.00	8.53	5.82	0.16

Emission factors for ROG, CO, NO_x, PM₁₀ from (Reclamation 2007)

Assume: Emission rates from 2011 to 2016 are equal to 2010
Eight hour work day

Construction Equipment Emission Rates (pounds per day) from Corps 2009

Equipment Type	ROG	CO	NO _x	PM ₁₀
Bore/Drill Rigs				
175 Horsepower	0.966	6.033	9.19	0.469
Pickups¹				
Pounds/1,000 miles	1.12	10.6	1.22	0.0905
Pounds/day	0.0672	0.636	0.0732	0.00543
Heavy-heavy duty diesel truck 2009²				
Pounds per mile	0.00739	0.03694	0.04495	0.0026
Pounds/day	0.4434	2.2164	2.697	0.156

Project will use 140 hp drills

¹ Assume: Pickups in use 4 hours per day, maximum speed is 15 mph, maximum distance per day is 60 miles.

² Assume: Trucks in use 4 hours per day, maximum speed is 15 mph, maximum distance per day is 60 miles.

Approximate 2010 annual unmitigated emissions:	0.05	0.30	0.46	0.023
Approximate 2011 annual unmitigated emissions:	2.30	17.96	15.19	0.55
Approximate 2012 annual unmitigated emissions:	0.69	5.59	4.20	0.13
Approximate 2013 annual unmitigated emissions:	0.34	2.80	2.10	0.07
Approximate 2014 annual unmitigated emissions:	1.44	11.65	8.61	0.27
Approximate 2015 annual unmitigated emissions:	1.29	10.42	7.77	0.25
Approximate 2016 annual unmitigated emissions:	1.29	10.42	7.77	0.25

Appendix A-2: Exhaust Emissions - Haul Trucks

Emissions: On-Site and Off-Site Haul Trucks Exhaust (Based on Vehicle Miles Traveled)

Assumptions and Emission Factors from: Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)

ON-SITE HAUL TRUCKS

EMISSION FACTORS

Vehicle Description	Emission Rate in grams per mile						
	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Heavy-Heavy Duty Diesel Truck 2009	16.75	2,516.08	20.39	1.18	1.05	0.02	3.35

Emission Factor from (Corps 2009) Appendix A: On-site Truck Emissions

Vehicle Description	Emission Rate in pounds per mile						
	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Heavy-Heavy Duty Diesel Truck 2009	0.02692	5.5469	0.04495	0.00269	0.00231	0.0000441	0.00739

Emission Factor calculated based on conversion factor of 0.0022046 to convert from grams to pounds

OFF-SITE HAUL TRUCKS

EMISSION FACTORS

Vehicle Description	Emission Rate in pounds per mile						
	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Heavy-Heavy Duty Diesel Truck 2009	0.010	4.21	0.040	0.00153	0.00132	0.0000301	0.00268

Emission Factor from (Corps 2009) Appendix A: Off-site Truck Emissions

CONTROL STRUCTURE - Excavation (9 months)

Jan - Sept 2011

Vehicle	Miles per round trip	Number of trips	Total Miles	Emissions in pounds							Emissions in tons						
				CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
"Super" dump truck (hauling to MIAD)	3	6,400	19,200	709	106,501	863	50	44	0.85	142	0.35	53.25	0.43	0.025	0.022	0.00042	0.071

Miles: 19,200

Total Emissions in tons							
CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG	
0.35	53.25	0.43	0.025	0.022	0.00042	0.071	TOTAL ON-SITE HAUL TRUCK EMISSIONS
0.35	53.25	0.43	0.025	0.022	0.00042	0.071	Average annual on-site haul truck emissions (9 months):

CONTROL STRUCTURE - Concrete Placement and Batch Plant (24 months) and Gate Installation (9 months)

Concrete Placement and Batch Plant - July 2011 through July 2013; Gate Installation - December 2013 through July 2014

Vehicle	Miles per trip	Number of trips	Total Miles	Emissions in pounds							Emissions in tons						
				CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Off-site deliveries of material	10	230	2,300	23.0	9,683	92	3.5	3.0	0.069	6.16	0.0115	4.84	0.046	0.0018	0.0015	0.000035	0.0031
Aggregate delivery for concrete	36	9,700	349,200	3,492.0	1,470,132	13,968	534	460.9	10,511	935.86	1,7460	735.07	6.98	0.2671	0.2305	0.0053	0.47
Delivery of reinforcing bars	10	66	660	6.6	2,779	26	1.0	0.9	0.020	1.77	0.0033	1.39	0.0132	0.0005	0.0004	0.000010	0.0009
Delivery of Bulkhead gates	30	6	180	1.8	758	7	0.3	0.2	0.005	0.48	0.0009	0.38	0.0036	0.00014	0.00012	0.000003	0.0002
Delivery of Taintor gates	30	6	180	1.8	758	7	0.3	0.2	0.005	0.48	0.0009	0.38	0.0036	0.00014	0.00012	0.000003	0.0002
Delivery of Trunion girders	30	6	180	1.8	758	7	0.28	0.24	0.005	0.48	0.0009	0.38	0.0036	0.00014	0.00012	0.000027	0.00024
Delivery of stairs and handrails	30	3	90	0.90	379	4	0.14	0.12	0.0027	0.24	0.0005	0.19	0.0018	0.000069	0.000059	0.0000014	0.00012
Delivery of walkways, steel grating	30	5	150	1.5	632	6	0.23	0.20	0.0045	0.40	0.0008	0.32	0.0030	0.00011	0.00010	0.0000023	0.00020
Delivery of trunnion and guides	30	12	360	3.6	1,516	14	0.55	0.48	0.011	0.96	0.0018	0.76	0.0072	0.00028	0.00024	0.0000054	0.00048
Delivery of misc. electrical, HVAC	10	1,200	12,000	120.0	50,520	480	18.4	15.8	0.361	32.16	0.0600	25.26	0.2400	0.0092	0.0079	0.00018	0.016
Delivery for construction of batch plant	20	10	200	2.0	842	8	0.3	0.3	0.006	0.54	0.0010	0.42	0.0040	0.0002	0.0001	0.00000	0.000
Delivery of concrete from off-site source	20	41	820	8.2	3,452	33	1.3	1.1	0.025	2.20	0.0041	1.73	0.0164	0.0006	0.0005	0.00001	0.001
Total				3,663.2	1,542,207.2	14,652.8	560.5	483.5	11.0	981.7	1.83	771.10	7.33	0.28	0.24	0.0055	0.49
Average Annual emissions (based on 33 months)				1,332.1	560,802.6	5,328.3	203.8	175.8	4.0	357.0	0.67	280.40	2.66	0.10	0.088	0.0020	0.18

Miles: 366,320

CHUTE AND STILLING BASIN - Concrete Placement and Batch Plant/Foundation Preparation/Backfill (36 months)

Late 2013 through 2016

Vehicle	Miles per trip	Number of trips	Total Miles	Emissions in pounds							Emissions in tons						
				CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Off-site deliveries of material	10	230	2,300	23.0	9,683	92	3.5	3.0	0.069	6.16	0.0115	4.84	0.046	0.0018	0.0015	0.000035	0.0031
Aggregate delivery for concrete	36	13,000	468,000	4,680.0	1,970,280	18,720	716	617.8	14,087	1,254.24	2,3400	985.14	9.36	0.3580	0.3089	0.0070	0.63
Delivery of reinforcing bars	10	169	1,690	16.9	7,115	68	2.6	2.2	0.051	4.53	0.0085	3.56	0.0338	0.0013	0.0011	0.000025	0.0023
Delivery of misc. electrical, HVAC	10	100	1,000	10.0	4,210	40	1.5	1.3	0.030	2.68	0.0050	2.11	0.0200	0.0008	0.0007	0.00002	0.001
Delivery of concrete from off-site source	20	40	800	8.0	3,368	32	1.2	1.1	0.024	2.14	0.0040	1.68	0.0160	0.0006	0.0005	0.00001	0.001
Total				4,737.9	1,994,655.9	18,951.6	724.9	625.4	14.3	1,269.8	2.37	997.33	9.48	0.36	0.31	0.0071	0.63
Average Annual emissions (based on 36 months)				1,579.3	664,885.3	6,317.2	241.6	208.5	4.8	423.3	0.79	332.44	3.16	0.12	0.10	0.0024	0.21

Miles: 473,790

TOTAL PROJECT OFF-SITE MILES (69 months) July 2011 through 2016

		Total Emissions in tons							
		CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG	
TOTAL OFF-SITE MILES:	840,110	4.2	1,768.4	16.8	0.64	0.55	0.0126	1.13	TOTAL OFF-SITE HAUL TRUCK EMISSIONS:
Average annual off-site truck miles (based on 69 months, or 5.75 years):	146,106	0.73	307.55	2.92	0.11	0.10	0.0022	0.20	Average annual off-site haul truck emissions (69 months, or 5.75 years):

Appendix A-2: Exhaust Emissions - Worker Commute

Emissions - Worker Commute Exhaust

Assumptions and Emission Factors from: Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)
Emission Factor from (Corps 2009)

Vehicle Description	Emission Rate in Pounds Per 1000 Miles						
	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Light Duty Automobile (LDA)	8.87	832	0.756	0.0694	0.0393	0.00786	0.991
Light Duty Truck (LDT)	10.6	1020	1.22	0.0905	0.0566	0.0131	1.12
Average based on 50 percent LDA and 50 percent LDT	9.75	927	0.99	0.08	0.0479	0.00959	1.06

Control Structure

		(Jan 2011 through July 2014)	
Workers	70	Period of Operation (months)	42
Workers per vehicle	2	Workdays per week	5
Commuter vehicles per day	35	Workdays per month	20
Vehicles from Sacramento (80%)	28	Workdays in period	840
Vehicles from Folsom (20%)	7		
Roundtrip to Sacramento (miles)	60	Operation (months) ¹	
Roundtrip to Folsom (miles)	10		
Daily Miles:	1,750	Excavation	9
Annual Miles:	420,000	Aggregate and concrete	24
COMMUTER MILES (42 months)	1,470,000	Gate installation	9
COMMUTER MILES (42 months)/1000	1470		42
		¹ Assume no overlap	

Emissions	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Total Pounds	14,332.50	1,362,690.00	1,455.30	117.60	70.41	14.10	1,558.20
Total Tons	7.17	681.35	0.73	0.059	0.035	0.0070	0.78
Average annual pounds	4,095.00	389,340.00	415.80	33.60	20.12	4.03	445.20
Average annual tons	2.05	194.67	0.21	0.017	0.010	0.0020	0.22

Chute and Stilling Basin

		(late 2013 through 2016)	
Workers	70	Period of Operation (months)	36
Workers per vehicle	2	Workdays per week	5
Commuter vehicles per day	35	Workdays per month	20
Vehicles from Sacramento (80%)	28	Workdays in period	720
Vehicles from Folsom (20%)	7		
Roundtrip to Sacramento (miles)	60		
Roundtrip to Folsom (miles)	10		
Daily Miles:	1,750		
Annual Miles:	420,000		
COMMUTER MILES (36 months)	1,260,000		
COMMUTER MILES (36 months)/1000	1,260		

Emissions	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Total Pounds	12,285.00	1,168,020.00	1,247.40	100.80	60.35	12.08	1,335.60
Total Tons	6.14	584.01	0.62	0.050	0.030	0.0060	0.67
Average annual pounds	4,095.00	389,340.00	415.80	33.60	20.12	4.03	445.20
Average annual tons	2.05	194.67	0.21	0.017	0.010	0.0020	0.22

Borings for Approach Channel Cofferdam

		(Oct 2010 through Jan 2011)	
Workers	4	Period of Operation (months)	4
Workers per vehicle	1	Workdays per week	5
Commuter vehicles per day	4	Workdays per month	20
Vehicles from Sacramento (100%)	4	Workdays in period	80
Vehicles from Folsom (0%)	0		
Roundtrip to Sacramento (miles)	60		
Roundtrip to Folsom (miles)	10		
Daily Miles:	240		
Annual Miles:	19,200		
COMMUTER MILES (4 months)	19,200		
COMMUTER MILES (4 months)/1000	19.2		

Emissions	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
Pounds	187.20	17,798.40	19.01	1.54	0.92	0.18	20.35
Tons	0.094	8.90	0.010	0.00077	0.00046	0.000092	0.010

Total Commuter Emissions	CO	CO ₂	NO _x	PM ₁₀	PM _{2.5}	SO _x	ROG
	26,804.70	2,548,508.40	2,721.71	219.94	131.69	26.36	2,914.15
	13.40	1,274.25	1.36	0.110	0.066	0.013	1.46

Total Commuter Vehicle Miles Traveled 2,749,200

Fugitive Dust - Cumulative Activities

PM₁₀ and Fugitive Dust Pollutants

Borings for Approach Channel Cofferdam

Based on AP-42 Table 11.9-4

TSP Emissions = 1.3 pounds per hole
 Assume: 100% TSP = PM₁₀; 15 borings -
 Tons per year
 Total annual average tons

(Oct 2010 through Jan 2011)

Period of Operation (months)

4

Unmitigated

PM ₁₀	PM _{2.5}
0.00975	0.00975
0.010	0.010

Mitigated

PM ₁₀	PM _{2.5}
0.00975	0.00975
0.010	0.010

No mitigations

Control Structure

(Jan 2011 through July 2014)

Period of Operation (months)

42

Excavation: 9 months - January through September, 2011**Aggregate and Concrete:** 24 months - July 2011 through July 2013**Gate Installation:** 9 months - December 2013 through July 2014

Excavation Cut and Fill

(Urbemis 2007)

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
18.36	3.8

Mitigated (55 % reduction)

(Basic Construction Emission Control Practices)

PM ₁₀	PM _{2.5}
8.3	1.7

Paved Road - Haul Truck

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
2.54	0.35

Mitigated (no mitigations)

PM ₁₀	PM _{2.5}
2.54	0.35

Paved Road - Worker Commuter Travel

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
0.084	0.0060

Mitigated (no mitigations)

PM ₁₀	PM _{2.5}
0.084	0.0060

Unpaved Road - Haul Truck

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
20.0	2.0

Mitigated (55 % reduction)

PM ₁₀	PM _{2.5}
9.0	0.91

Material Storage Pile Handling - Excavation

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
0.025	0.0038

Mitigated (90% reduction)

PM ₁₀	PM _{2.5}
0.0025	0.00038

Material Storage Pile Handling - Aggregate

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
0.0038	0.00057

Mitigated (90% reduction)

PM ₁₀	PM _{2.5}
0.00038	0.000057

Stockpile Wind Erosion - Excavation

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
17.9	2.7

Mitigated (90% reduction)

PM ₁₀	PM _{2.5}
1.79	0.27

Stockpile Wind Erosion - Aggregate

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
3.6	0.54

Mitigated (90% reduction)

PM ₁₀	PM _{2.5}
0.36	0.054

Blasting (with Drilling)

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
20.4	0.00

Mitigated

PM ₁₀	PM _{2.5}
11.0	0.00

Concrete Batch Plant

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
97.0	0.00

Mitigated

PM ₁₀	PM _{2.5}
1.6	0.00

Total Avg Tons per year (Control Structure)

179.8	9.4
-------	-----

34.7	3.3
------	-----

(late 2013 through 2016)

Period of Operation (months)

36

Paved Road - Haul Truck

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
3.02	0.42

Mitigated (no mitigations)

PM ₁₀	PM _{2.5}
3.02	0.42

Paved Road - Worker Commuter Travel

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
0.084	0.0060

Mitigated (no mitigations)

PM ₁₀	PM _{2.5}
0.084	0.0060

Material Storage Pile Handling - Excavation¹

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
0.025	0.0038

Mitigated (90% reduction)

PM ₁₀	PM _{2.5}
0.0025	0.00038

Material Storage Pile Handling - Aggregate

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
0.0055	0.00083

Mitigated (90% reduction)

PM ₁₀	PM _{2.5}
0.00055	0.000083

Stockpile Wind Erosion - Aggregate

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
5.2	0.79

Mitigated (90% reduction)

PM ₁₀	PM _{2.5}
0.52	0.079

Concrete Batch Plant

Tons per year

Unmitigated

PM ₁₀	PM _{2.5}
84.9	0.00

Mitigated

PM ₁₀	PM _{2.5}
1.4	0.00

Total Avg Tons per year (Chute and Stilling Basin)

93.23	1.22
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5.03	0.51
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¹ Although excavation is not planned during the chute and stilling basin construction phase, PM₁₀ emissions are listed to give the most conservative estimate.

Appendix A-2: Fugitive Dust - Paved Roads

FUGITIVE DUST Emissions: Paved Roads

Methodology from AP-42, Fifth Edition, Volume 1 Chapter 13.2.1: Paved Roads

Assumptions and Emission Factors from Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)

VMT = Vehicle Miles Traveled

Assumptions for Worker Commuter Travel based on Corps 2009.

Worker commuter fleet is 50 percent light duty automobile (LDA) and 50 percent light duty truck (LDT).
Average Vehicle Weight (W) is 1.75 tons.

Roadway Surface Type	Travel Fraction	PM ₁₀ Particulate Emission Factor (lb/VMF)	PM ₁₀ Long-Term Particulate Emission Factor (lb/VMF)	PM _{2.5} Particulate Emission Factor (lb/VMF)	PM _{2.5} Long-Term Particulate Emission Factor (lb/VMF)
Freeway	0.235	<0	<0	<0	<0
Arterial/Major street	0.587	0.000044	0.0000413	<0	<0
Collector Road	0.072	0.000044	0.0000413	<0	<0
Local Road	0.052	0.0017	0.00159	<0	<0
Rural Road	0.054	0.0057	0.00534	0.000565	0.00053

Note: AP-42, Fifth Edition, Volume 1 Chapter 13.2.1, page 13.2.1-5 states "There may be situations where low silt loading and/or low average weight will yield calculated negative emissions. If this occurs, the emissions calculated from the equation should be set to zero.

Fugitive Dust Annual Emission Calculations for Worker Commuter Travel.

Maximum annual commuter miles traveled: 420,000

*Both Control Structure and Chute and Stilling Basin

*January 2011 through 2016

Total commuter miles traveled for entire project: 2,749,200

Roadway surface	Annual VMT (miles)	Annual PM ₁₀ Emissions (ton/year)	Annual PM ₁₀ Annual Long-Term Emissions (ton/year)	Annual PM _{2.5} Emissions (ton/year)	Annual PM _{2.5} Annual Long-Term Emissions (ton/year)
Freeway	98,700	0	0	0	0
Arterial/Major street	246,540	0.0054	0.0051	0	0
Collector Road	30,240	0.00067	0.00062	0	0
Local Road	21,840	0.019	0.017	0	0
Rural Road	22,680	0.065	0.061	0.0064	0.0060
Totals:		0.089	0.084	0.006	0.0060

Assumptions for Heavy Heavy Diesel Truck Travel based on Corps 2009.

Average Vehicle Weight (W) is 23.25 tons.

Roadway Surface Type	Travel Fraction	PM ₁₀ Particulate Emission Factor (lb/VMF)	PM ₁₀ Long-Term Particulate Emission Factor (lb/VMF)	PM _{2.5} Particulate Emission Factor (lb/VMF)	PM _{2.5} Long-Term Particulate Emission Factor (lb/VMF)
Freeway	0.235	0.02	0.02	0.00224	0.0021
Arterial/Major street	0.587	0.02	0.02	0.00337	0.00317
Collector Road	0.072	0.02	0.02	0.00337	0.00317
Local Road	0.052	0.1	0.1	0.02	0.01
Rural Road	0.054	0.3	0.28	0.04	0.04

Note: Long-term particulate emission factor considers natural mitigation with precipitation.

CONTROL STRUCTURE - Fugitive Dust Annual Emission Calculations for Off-Site Truck Travel

Total off-site truck miles: 366,320 Months: 33

Average annual off-site truck miles: 133,207

Roadway surface	Annual VMT (miles)	Annual PM ₁₀ Emissions (ton/year)	Annual PM ₁₀ Annual Long-Term Emissions (ton/year)	Annual PM _{2.5} Emissions (ton/year)	Annual PM _{2.5} Annual Long-Term Emissions (ton/year)
Freeway	31,304	0.31	0.31	0.035	0.033
Arterial/Major street	78,193	0.78	0.78	0.13	0.12
Collector Road	9,591	0.10	0.10	0.016	0.015
Local Road	6,927	0.35	0.35	0.07	0.035
Rural Road	7,193	1.08	1.01	0.14	0.144
		2.62	2.54	0.40	0.35

Notes: Total off-site truck miles calculated on "On-Site and Off-Site Haul Trucks Exhaust" page
Assumes 24 months for concrete placement and 9 months for gate installation.

CHUTE and STILLING BASIN - Fugitive Dust Annual Emission Calculations for Off-Site Truck Travel

Total off-site truck miles: 473,790 Months: 36

Average annual off-site truck miles: 157,930

Roadway surface	Annual VMT (miles)	Annual PM ₁₀ Emissions (ton/year)	Annual PM ₁₀ Annual Long-Term Emissions (ton/year)	Annual PM _{2.5} Emissions (ton/year)	Annual PM _{2.5} Annual Long-Term Emissions (ton/year)
Freeway	37,114	0.37	0.37	0.042	0.039
Arterial/Major street	92,705	0.93	0.93	0.16	0.15
Collector Road	11,371	0.11	0.11	0.019	0.018
Local Road	8,212	0.41	0.41	0.08	0.041
Rural Road	8,528	1.28	1.19	0.17	0.17
		3.10	3.02	0.47	0.42

Notes: Total off-site truck miles calculated on "On-Site and Off-Site Haul Trucks Exhaust" page

Appendix A-2: Fugitive Dust - Unpaved Roads

FUGITIVE DUST Emissions: Unpaved Roads

Methodology from AP-42 , Fifth Edition, Volume 1 Chapter 13.2.2: Unpaved Roads

Assumptions and Emission Factors from: Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)

VMТ = Vehicle Miles Traveled

Assumptions for Heavy Heavy Diesel Truck Travel based on Corps 2009.

Average Vehicle Weight (W) is 23.25 tons.

	PM ₁₀ Particulate Emission Factor (lb/VMТ)	PM ₁₀ Long-Term Particulate Emission Factor [Naturally Mitigated] (lb/VMТ)	PM _{2.5} Particulate Emission Factor (lb/VMТ)	PM _{2.5} Long-Term Particulate Emission Factor [Naturally Mitigated] (lb/VMТ)
Unpaved Road	2.76	2.08	0.28	0.21

Note: Long-term particulate emission factor considers natural mitigation with precipitation.

Fugitive Dust Annual Emission Calculations for On-Site Truck Travel during excavation.

Nine months on-site truck miles: 19,200
(excavation hauling to MIAD)

Roadway surface	Annual VMТ (miles)	Unmitigated Annual PM ₁₀ Emissions (ton/year)	Annual PM ₁₀ Annual Long- Term Emissions [Naturally Mitigated] (ton/year)	Unmitigated Annual PM _{2.5} Emissions (ton/year)	Annual PM _{2.5} Annual Long- Term Emissions [Naturally Mitigated] (ton/year)
Unpaved Road	19,200	26.50	19.97	2.69	2.02

55 percent control factor for road dust for watering twice a day. Mitigated emission:

8.9856

0.9072

MIAD Mormon Island Auxiliary Dam (disposal and course material stockpiling for U.S. Army Corps of Engineers).

FUGITIVE DUST Emissions: Excavated Material Storage Piles

Methodology from AP-42 , Fifth Edition, Volume 1 Chapter 13.2.4: Aggregate Handling and Storage Piles

Assumptions and Emission Factors from: Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)

Assumptions for Excavation Stockpile Handling Emissions based on Corps 2009.

Mean wind speed (mph)	5.1
Material moisture content (%)	7.9
Density of weathered granite (lb/cy)	1,850
Wet suppression controls (%)	90

Emission factor for PM ₁₀ stockpile emissions (lb/ton):	0.000168
Emission factor for PM _{2.5} stockpile emissions (lb/ton):	0.0000254

mph = miles per hour

% = percent

lb/cy = pounds per cubic yard

lb/ton = pounds per ton

Fugitive Dust Emission Calculations for Excavation Stockpile Handling

Period of Excavation (months):	9
Common Excavation (cy) ¹ :	20,000
Rock Excavation (cy) ¹ :	300,000
Total Excavation (cy) ¹ :	320,000

Stockpile amount (tons):	296,000
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Parameter	Stockpile Amount (tons)	Emission Factor (lb/ton)	Emission Controls (percent)	Unmitigated emissions (tons/year)	Mitigated emissions (tons/year)
PM ₁₀	296,000	0.000168	90	0.025	0.0025
PM _{2.5}	296,000	0.0000254	90	0.0038	0.00038

¹ Based on Folsom Dam JFP Teleconference Notes, Air Analysis Revisions, June 8, 2010

Assumptions: The excavated material will be added to the storage pile during construction of the Control Structure.
The excavated material will still be in place during the Chute and Stilling Basin construction phase.

FUGITIVE DUST Emissions: Aggregate Material Storage Piles (for concrete batch plants)

Methodology from AP-42, Fifth Edition, Volume 1 Chapter 13.2.4: Aggregate Handling and Storage Piles

Assumptions and Emission Factors from: Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)

Assumptions for Excavation Stockpile Handling Emissions based on Corps 2009.

Mean wind speed (mph)	5.1
Material moisture content (%)	7.9
Density of weathered granite (lb/cy)	1,850
Wet suppression controls (%)	90

Emission factor for PM ₁₀ stockpile emissions (lb/ton):	0.000168
Emission factor for PM _{2.5} stockpile emissions (lb/ton):	0.0000254

Fugitive Dust Emission Calculations for Aggregate Stockpile Handling

Control Structure Concrete Emplacement (months):	24
Chute and Stilling Basin Concrete Emplacement (months):	36
Total Control Structure Aggregate (cy) ¹ :	97,000
Total Chute and Stilling Basin Aggregate (cy) ² :	211,068
Entire Project Length - Total Aggregate (cy):	308,068

Annual Control Structure Aggregate (cy):	48,500
Annual Chute and Stilling Basin Aggregate (cy):	70,356

Entire Project Length - Total Aggregate (tons):	284,963
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Annual Control Structure Aggregate (tons):	44,863
Annual Chute and Stilling Basin Aggregate (tons):	65,079

mph = miles per hour

% = percent

lb/cy = pounds per cubic yard

lb/ton = pounds per ton

Parameter	Control Structure					Chute and Stilling Basin				
	Annual Stockpile Amount (tons)	Emission Factor (lb/ton)	Emission Controls (percent)	Unmitigated emissions (tons/year)	Mitigated emissions (tons/year)	Annual Stockpile Amount (tons)	Emission Factor (lb/ton)	Emission Controls (percent)	Unmitigated emissions (tons/year)	Mitigated emissions (tons/year)
PM ₁₀	44,863	0.000168	90	0.0038	0.00038	65,079	0.000168	90	0.0055	0.00055
PM _{2.5}	44,863	0.0000254	90	0.00057	0.000057	65,079	0.0000254	90	0.00083	0.000083

¹ Based on March 5, 2010, equipment list spreadsheet (equipmentjfrMarch 5.xls)

² Based on June 15, 2010, email attachment from Jane Rinck to Garrett Smith and Leroy Shaser (commentary.docx).

FUGITIVE DUST Emissions: Excavated Stockpile Wind Erosion

Methodology from AP-42, Fifth Edition, Volume 1 Chapter 13.2.5: Industrial Wind Erosion

Assumptions and Emission Factors from: Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)

$$\text{Emission Factor (EF) in g/m}^2 = k \sum_{i=1}^N P_i$$

Where:

k = Particle Size Multiplier (dimensionless)

N = Number of Disturbances per Year

 P_i = Erosion Potential Corresponding to the Observed Fastest Mile of Wind for the i th Period Between DisturbancesAssumptions for Stockpile Wind Erosion Emissions based on Corps 2009.

k for PM ₁₀	0.5
k for PM _{2.5}	0.075
P_i : Erosion Potential (g/m ²)	7.37
Wet suppression controls (%)	90

cy = cubic yards

g = gram

m = meter

% = percent

Fugitive Dust Emission Calculations for Stockpile Wind Erosion

Period of Excavation (months):	9
Workdays per Month:	20
Total workdays:	180
N = Number of Disturbances (assume one per workday)	180
Total Material Excavated and Stored: (cy) ¹ :	320,000
Total Material Excavated and Stored: (cubic m) ² :	244,659

PM ₁₀ EF (g/m ²) =	663.3
PM _{2.5} EF (g/m ²) =	99.495

Stockpile Area (sq m) ³ :	24,465.9
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Parameter	Emission Factor (g/m ²)	Stockpile Area (m ²)	Emission Controls (percent)	Unmitigated emissions (g/year)	Mitigated emissions (g/year)	Unmitigated emissions ⁴ (tons/year)	Mitigated emissions ⁴ (tons/year)
PM ₁₀	663.3	24,465.9	90	16,228,245	1,622,824	17.9	1.79
PM _{2.5}	99.50	24,465.9	90	2,434,237	243,424	2.68	0.27

¹ Based on Project Description² Conversion Factor: Cubic Yard * 0.76456 = Cubic Meter³ Assume Stockpile is 10 Meters Deep⁴ Conversion Factor: Grams*0.0000011023 = Ton

FUGITIVE DUST Emissions: Aggregate Stockpile Wind Erosion (for concrete batch plants)

Methodology from AP-42, Fifth Edition, Volume 1 Chapter 13.2.5: Industrial Wind Erosion

Assumptions and Emission Factors from: Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009)

$$\text{Emission Factor (EF) in g/m}^2 = k \sum_{i=1}^N P_i$$

Where:

k = Particle Size Multiplier (dimensionless)

N = Number of Disturbances per Year

P_i = Erosion Potential Corresponding to the Observed Fastest Mile of Wind for the ith Period Between Disturbances

Assumptions for Stockpile Wind Erosion Emissions based on Corps 2009.

k for PM ₁₀	0.5
k for PM _{2.5}	0.075
P _i : Erosion Potential (g/m ²)	7.37
Wet suppression controls (%)	90

Fugitive Dust Emission Calculations for Stockpile Wind Erosion

Control Structure Concrete Placement (months):	24
Chute and Stilling Basin Concrete Placement (months):	36
Total Control Structure Aggregate (cy) ^a	97,000
Annual - Control Structure Aggregate (cy)	48,500
Annual - Control Structure Aggregate (cubic m) ¹	37,081
Total Chute and Stilling Basin Aggregate (cy) ^b	211,068
Annual - Chute and Stilling Basin Aggregate (cy)	70,356
Annual - Chute and Stilling Basin Aggregate (cubic m) ¹	53,791

Annual Workdays: 240

Annual Workdays: 240

N = Assume one disturbance per workday

PM₁₀ EF (g/m²) = 884.4

PM_{2.5} EF (g/m²) = 132.7

Annual Control Structure Stockpile Area²: 3,708 square meter

Annual Chute and Stilling Basin Stockpile Area²: 5,379 square meter

cy = cubic yards

g = gram

m = meter

% = percent

¹ Conversion Factor: Cubic Yard * 0.76456 = Cubic Meter

² Assume Stockpile is 10 Meters Deep

³ Conversion Factor: Grams*0.0000011023 = Ton

Control Structure							
Parameter	Emission Factor (g/m ²)	Annual Stockpile Area (m ²)	Emission Controls (percent)	Unmitigated emissions (g/year)	Mitigated emissions (g/year)	Unmitigated emissions ⁴ (tons/year)	Mitigated emissions ⁴ (tons/year)
PM ₁₀	884.4	3,708.1	90	3,279,458	327,946	3.6	0.36
PM _{2.5}	132.66	3,708.1	90	491,919	49,192	0.54	0.054

Chute and Spilling Basin							
Parameter	Emission Factor (g/m ²)	Annual Stockpile Area (m ²)	Emission Controls (percent)	Unmitigated emissions (g/year)	Mitigated emissions (g/year)	Unmitigated emissions ⁴ (tons/year)	Mitigated emissions ⁴ (tons/year)
PM ₁₀	884.4	5,379.1	90	4,757,310	475,731	5.2	0.52
PM _{2.5}	132.66	5,379.1	90	713,596	71,360	0.79	0.079

^a Based on March 5, 2010, equipment list spreadsheet (equipmentjfrMarch 5.xls)

^b Based on June 15, 2010, email attachment from Jane Rinck to Garrett Smith and Leroy Shaser (commentary.docx)

Appendix A-2: Fugitive Dust - Concrete Batch Plant

FUGITIVE DUST Emissions: Concrete Batch Plant

Methodology and Assumptions from AP-42, Fifth Edition, Volume 1 Chapter 11.12: Concrete Batching

Emission Factors from AP-42 11.12 Concrete Batching

PM₁₀ emissions in pounds per ton of concrete:

Batch Plant Source	Uncontrolled	Controlled
Aggregate transfer	0.0033	ND
Sand transfer	0.00099	ND
Cement unloading to elevated storage silo (pneumatic)	0.46	0.00034
Cement supplement unloading to elevated storage silo (pneumatic)	1.10	0.0049
Weigh hopper loading	0.0024	ND
Mixer loading (central mix)	0.134	0.0048
Truck loading (truck mix)	0.278	0.016
Total	1.98	0.033

Note: Controlled Total is calculated by adding data from "Controlled" column with data from "Uncontrolled" column when "Controlled" is ND.

One cubic yard of concrete (lbs) 4,024

ND = No Data
cy = cubic yards

Fugitive Dust Emission Calculations for Control Structure

Period of Batch Plant Operation (months):	24
Aggregate (cy)	97,000
Concrete Placement (cy) ¹ :	97,234
Concrete Placement (tons):	195,635

Parameter	Annual Concrete Placement (tons)	Unmitigated emissions (pounds/year)	Controlled emissions (pounds/year)	Unmitigated emissions (tons/year)	Controlled emissions (tons/year)
PM ₁₀	97,817	193,550	3,202	97	1.6

¹ Based on Project Description

Fugitive Dust Emission Calculations for Chute and Stilling Basin

Period of Batch Plant Operation (months):	36
Aggregate (cy)	211,068
Concrete Placement -Chute (cy):	99,625
Concrete Placement -Stilling Basin (cy):	28,295
Concrete Placement -Total (cy):	127,920
Concrete Placement (tons):	257,375

Parameter	Annual Concrete Placement (tons)	Unmitigated emissions (pounds/year)	Controlled emissions (pounds/year)	Unmitigated emissions (tons/year)	Controlled emissions (tons/year)
PM ₁₀	85,792	169,755	2,808	84.9	1.4

Appendix A-2: Fugitive Dust - Cut and Fill (Excavation)

Urbemis 2007 Version 9.2.4

Detail Report for Annual Construction Unmitigated Emissions (Tons/Year)

File Name: F:\I-drive\G018 Sacramento\Workfiles\Urbemis\Folsom_Control_Structure1_06-11-10.urb924

Project Name: Folsom Dam Control Structure Excavation

Project Location: Sacramento County AQMD

On-Road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-Road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Annual Tons Per Year, Unmitigated)

	<u>ROG</u>	<u>NOx</u>	<u>CO</u>	<u>SO2</u>	<u>PM10 Dust</u>	<u>PM10 Exhaust</u>	<u>PM10 Total</u>	<u>PM2.5 Dust</u>	<u>PM2.5 Exhaust</u>	<u>PM2.5 Total</u>	<u>CO2</u>
2011	0.00	0.00	0.00	0.00	18.36	0.00	18.36	3.83	0.00	3.83	0.00
Mass Grading 01/17/2011-	0.00	0.00	0.00	0.00	18.36	0.00	18.36	3.83	0.00	3.83	0.00
Mass Grading Dust	0.00	0.00	0.00	0.00	18.36	0.00	18.36	3.83	0.00	3.83	0.00
Mass Grading Off Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading On Road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Worker Trips	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Phase Assumptions

Phase: Mass Grading 1/17/2011 - 9/16/2011 - Folsom Dam Control Structure Excavation

Total Acres Disturbed: 0

Maximum Daily Acreage Disturbed: 0

Fugitive Dust Level of Detail: Low

Onsite Cut/Fill: 1777.78 cubic yards/day; Offsite Cut/Fill: 0 cubic yards/day

On Road Truck Travel (VMT): 0

Off-Road Equipment:

Appendix A-2: Fugitive Dust - Blasting and Associated Drilling

FUGITIVE DUST Emissions: Blasting and Associated Drilling

Blasting Methodology from Blue Rock Quarry Draft Environmental Impact Report (Sonoma County 2005)

Equation:

$$EF = 0.2 * 961 (A)^{0.8} / [(D)^{1.8} (M)^{1.9}]$$

Where:

EF = Emission Factor

A= Blast Area

D= Depth of Blast

M= Moisture Content

Two blast sizes would be used during excavation: 50% of excavation with a blast volume of 2,778 cubic yards and 50% of excavation with a blast volume of 1,389 cubic yards. Assume 300,000 total cubic yards of excavation.

Information: Blasting dimensions provided by Kim Jorgensen in email to Garrett Smith (March 18, 2010)

Blast size #1 (2,778 cubic yards)

Cubic yards: 150,012

Fugitive Dust from Blast

Depth of Blast (ft)	20
Moisture content of material (%)	2
Blast Area (sq ft)	3,750
Number of blasts:	54
Number of holes per blast:	150

Depth of approximately 20 feet
Moisture content from (Corps 2009) Appendix A: Blasting Emissions
Assumes 75 feet wide (wall) by 50 feet burden

Total number of holes: 8,100

pounds per blast

PM₁₀

PM₁₀

Emission Factor=	169.50
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Total Emissions (lbs)	9,152.95
Total Emissions (tons)	4.58

Fugitive Dust from Drilling

Emission factor (lbs/hole)	1.3
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TSP: Methodology from AP-42, Table 11.9-4

TSP

TSP (Most Conservative Assumption: Assume 100% TSP is PM₁₀)

Total Emissions (lbs)	10,530.0
Total Emissions (tons)	5.27

Unmitigated Total PM₁₀ from Blasting (tons) 9.83

Mitigated Total PM₁₀ from Blasting(tons) 6.3

Unmitigated Total PM₁₀ from Drilling (tons) 10.53

Mitigated Total PM₁₀ from Drilling (tons) 4.7

Unmitigated Total PM₁₀ from Blasting and Drilling (tons) 20.36

Mitigated Total PM₁₀ from Blasting and Drilling (tons) 11.03

Blast size #2 (1,389 cubic yards)

Cubic yards: 150,012

Fugitive Dust from Blast

Depth of Blast (ft)	20
Moisture content of material (%)	2
Blast Area (sq ft)	1,875
Number of blasts:	108
Number of holes per blast:	75

Depth of approximately 20 feet
Moisture content from (Corps 2009) Appendix A: Blasting Emissions
Assumes 75 feet wide (wall) by 25 feet burden

Total number of holes: 8,100

pounds per blast

PM₁₀

PM₁₀

Emission Factor=	97.35
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Total Emissions (lbs)	10,513.98
Total Emissions (tons)	5.26

Fugitive Dust from Drilling

Emission factor (lbs/hole)	1.3
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TSP: Methodology from AP-42, Table 11.9-4

TSP

TSP (Most Conservative Assumption: Assume 100% TSP is PM₁₀)

Total Emissions (lbs)	10,530.0
Total Emissions (tons)	5.27

Assume 36% control efficiency (Folsom Dam Safety and Flood Damage Reduction Early Approach Channel Excavation Final EA/IS (Corps 2009))

Assume 55% reduction from soil disturbance activities (SMAQMD, 2009))

GHG Emissions - Cumulative Summary from all Activities**Unmitigated Carbon Dioxide Emissions****Borings for Approach Channel Cofferdam**

(Oct 2010 through Jan 2011)

Period of Operation (months)

4

Worker Commute Emissions

CO ₂	
Average annual tons	Average annual metric tons
8.9	8.1

Construction Equipment Exhaust

CO ₂	
Average annual tons	Average annual metric tons
56	51

Summation

65	59
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Control Structure

(Jan 2011 through July 2014)

Period of Operation (months)

42

Worker Commute Emissions (Both Excavation and Concrete Emplacement)

CO ₂	
Average annual tons	Average annual metric tons
195	177

Construction Equipment Exhaust

CO ₂	
	Average annual metric tons
Excavation	3,382
Concrete Placement and Batch Plant	1,064
Gate Installation	90

On-Site Haul Truck

CO ₂	
Average annual tons	Average annual metric tons
53	48

Excavation

Off-Site Haul Truck

CO ₂	
Average annual tons	Average annual metric tons
280	254

Concrete Batch Plant

CO ₂	
Average annual tons	Average annual metric tons
13,111	11,895

Summation: Maximum average annual emissions

17,021	15,441
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Value calculated using Control Structure Excavation CO₂ emissions for construction equipment exhaust.**Chute and Stilling Basin**

(late 2013 through 2016)

Period of Operation (months)

36

Worker Commute Emissions

CO ₂	
Average annual tons	Average annual metric tons
195	177

Construction Equipment Exhaust

CO ₂	
Average annual tons	Average annual metric tons
2,591	2,351

Off-Site Haul Truck

CO ₂	
Average annual tons	Average annual metric tons
332	301

Concrete Batch Plant

CO ₂	
Average annual tons	Average annual metric tons
11,499	10,432

Summation

14,617	13,260
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Carbon dioxide emission values derived from other calculation spreadsheets and copied to this summary sheet.

Appendix A-2: GHG - Concrete Batch Plant

GHG Emissions: Concrete Batch Plant

Emission Factor from Flowers and Sanjayan, 2007 (Abstract): "Green House Gas Emissions Due to Concrete Manufacture,
The International Journal of Life Cycle Assessment. Vol 12, Number 5, July 2007. Landsberg, Germany: Ecomed.

CO ₂ emissions in kilograms per cubic meter of concrete:	320
CO ₂ emissions in kilograms per cubic yard of concrete:	244.7
CO ₂ emissions in kilograms per ton of concrete:	121.6

To convert cubic meter to cubic yard (multiply by): 1.3079
To convert cubic yard to cubic meter (multiply by): 0.76456

One cubic yard of concrete (lbs) 4,024

cy = cubic yards

Carbon Dioxide Emission Calculations for Control Structure

Period of Batch Plant Operation (months):	24
Aggregate (cy)	97,000
Concrete Placement (cy) ¹ :	97,234
Concrete Placement (tons):	195,635

Parameter	Annual Concrete Placement (tons)	Emission Factor (kg/ton)	CO ₂ emissions (kg/year)	CO ₂ emissions (metric tons/year)	CO ₂ emissions (tons/year)
CO ₂	97,817	121.6	11,894,596	11,895	13,111

¹ Based on Project Description

Carbon Dioxide Emission Calculations for Chute and Stilling Basin

Period of Batch Plant Operation (months):	36
Aggregate (cy)	211,068
Concrete Placement -Chute (cy):	99,625
Concrete Placement -Stilling Basin (cy):	28,295
Concrete Placement -Total (cy) ² :	127,920
Concrete Placement (tons):	257,375

Parameter	Annual Concrete Placement (tons)	Emission Factor (kg/ton)	CO ₂ emissions (kg/year)	CO ₂ emissions (metric tons/year)	CO ₂ emissions (tons/year)
CO ₂	85,792	121.6	10,432,268	10,432	11,499

² Based on June 15, 2010, email attachment from Jane Rinck to Garrett Smith and Leroy Shaser (commentary.docx).

GHG Emissions - Construction Equipment Exhaust

Equipment

Type	Number	Hours per day	Days per week	Months		Hours per week	Hours per Project	Calculated 8-hour days per Project	CO ₂ Emission Factor (g/hr)	Emissions (grams) CO ₂	Total Unmitigated CO ₂ Emissions Kilograms	Metric Tons	Tons	Unmitigated Estimated Annual Emissions*					
CONTROL STRUCTURE - Concrete Placement and Batch Plant 24 Months									July 2011 through July 2013						*Assume emissions spread out over 24 months				
Semi-trailer truck	20	4	5	12		400	19,200	2,400											
Belly dump truck	8	4	3	16		96	6,144	768											
Tanker trucks	2	4	3	16		24	1,536	192											
Chiller	1	10	5	12		50	2,400	300	115,321	276,769,560	276,770	276.77	305.08	138,385	138	153			
Stationary Cranes - electric	2	8	5	12		80	3,840	480	0	0	0	0	0	0	0	0			
Forklifts	2	4	5	12		40	1,920	240	116,379	223,447,085	223,447	223.45	246.31	111,724	112	123			
Man lift/scissor lift - electric	2	8	5	12		80	3,840	480	0	0	0	0	0	0	0	0			
Water truck	1	4	5	12		20	960	120	283,370	272,035,238	272,035	272.04	299.86	136,018	136	150			
Street sweeper	1	8	1	12		8	384	48	115,321	44,283,130	44,283	44.28	48.81	22,142	22	24			
Jackhammers	2	8	1	12		16	768	96	115,321	88,566,259	88,566	88.57	97.63	44,283	44	49			
Cement mixers (transit)	0	4	5	12		0	0	0	115,321	0	0	0.00	0.00	0	0	0			
Front end loaders	2	8	5	8		80	2,560	320	23,463	60,066,381	60,066	60.07	66.21	30,033	30	33			
Flatbed delivery truck	1		5						Off-site Haul Truck calculations										
Control Structure Concrete Placement Emissions											965,168	965	1,064		482,584	483	532		
CONTROL STRUCTURE - Excavation (9 months)									Jan - Sept 2011										
"Super" dump trucks	5	8	5	6		200	4,800	600											
Water trucks	1	4	5	6		20	480	60											
Fuel truck	1	2	5	8		10	320	40	283,370	136,017,619	136,018	136.02	149.93	136,018	136	150			
Maintenance truck	4	4	5	8		80	2,560	320	115,321	36,902,608	36,903	36.90	40.68	36,903	37	41			
Pickup trucks	10	4	5	8		200	6,400	800	115,321	295,220,864	295,221	295.22	325.42	295,221	295	325			
Drills for grouting - electric	6	8	5	9		240	8,640	1,080	115,321	738,052,160	738,052	738.05	813.55	738,052	738	814			
Rock drills for setting charges	NE	NE	NE	NE	NE	NE	7,353	919	0	0	0	0.00	0.00	0	0	0			
Front end loaders	2	8	5	8		80	2,560	320	63,991	470,527,220	470,527	470.53	518.66	470,527	471	519			
Dozers with rippers	2	8	5	8		80	2,560	320	23,463	60,066,381	60,066	60.07	66.21	60,066	60	66			
Backhoes	4	8	5	8		160	5,120	640	210,778	539,592,653	539,593	539.59	594.79	539,593	540	595			
Graders	2	8	5	8		80	2,560	320	23,463	120,132,762	120,133	120.13	132.42	120,133	120	132			
Scrapers	3	8	5	3		120	1,440	180	104,092	266,476,442	266,476	266.48	293.74	266,476	266	294			
Excavators	2	8	5	5		80	1,600	200	209,948	209,948,472	209,948	209.95	231.43	209,948	210	231			
Compactor sheep foot	2	8	5	3		80	960	120	106,021	169,632,960	169,633	169.63	186.99	169,633	170	187			
NE = Not Estimated									26,757	25,686,566	25,687	25.69	28.31	25,687	26	28			
Control Structure Excavation Emissions											3,068,257	3,068	3,382		3,068,257	3,068	3,382		
CONTROL STRUCTURE - Gate Installation (9 months)									December 2013 through July 2014										
Track driven cranes	2	8	5	5		80	1,600	200	50,874	81,399,088	81,399	81.40	89.73	81,399	81	90			
Flat bed trucks									Off-site Haul Truck calculations										
Control Structure Gate Installation Emissions											81,399	81	90		81,399	81	90		
CHUTE AND STILLING BASIN - Concrete Placement and Batch Plant (36 months)									Late 2013 through 2016										
Semi-trailer truck	20	4	5	36		400	57,600	7,200											
Belly dump truck	8	4	3	36		96	13,824	1,728											
Tanker trucks	2	4	3	36		24	3,456	432	115,321	398,548,166	398,548	398.55	439.32	132,849	133	146			
Chiller	1	10	5	36		50	7,200	900	115,321	830,308,680	830,309	830.31	915.25	276,770	277	305			
Stationary Cranes - electric	2	8	5	36		80	11,520	1,440	0	0	0	0.00	0.00	0	0	0			
Forklifts	2	4	5	36		40	5,760	720	116,379	670,341,254	670,341	670.34	738.92	223,447	223	246			
Man lift/scissor lift - electric	2	8	5	36		80	11,520	1,440	0	0	0	0.00	0.00	0	0	0			
Water truck	1	4	5	36		20	2,880	360	283,370	816,105,715	816,106	816.11	899.59	272,035	272	300			
Street sweeper	1	8	1	36		8	1,152	144	115,321	132,849,389	132,849	132.85	146.44	44,283	44	49			
Jackhammers	2	8	1	36		16	2,304	288	115,321	265,698,778	265,699	265.70	292.88	88,566	89	98			
Cement mixers (transit)	0	4	5	36		0	0	0	115,321	0	0	0.00	0.00	0	0	0			
Front end loaders	2	8	5	36		80	11,520	1,440	23,463	270,298,714	270,299	270.30	297.95	90,100	90	99			
Flatbed delivery truck	1		5						Off-site Haul Truck calculations										
CHUTE AND STILLING BASIN - Foundation Preparation/Backfill (36 months)											Late 2013 through 2016								
Fuel truck	1	2	5	36		10	1,440	180	115,321	166,061,736	166,062	166.06	183.05	55,354	55	61			
Water truck	1	4	5	36		20	2,880	360	283,370	816,105,715	816,106	816.11	899.59	272,035	272	300			
Front end loader	1	4	5	36		20	2,880	360	23,463	67,574,678	67,575	67.57	74.49	22,525	23	25			
Pickup trucks	5	4	5	36		100	14,400	1,800	115,321	1,660,617,360	1,660,617	1,660.62	1,830.50	553,539	554	610			
Track driven cranes	2	4	5	24		40	3,840	480	50,874	195,357,811	195,358	195.36	215.34	97,679	98	108			
Drills for grouting - electric	6	8	5	24		240	23,040	2,880	0	0	0	0.00	0.00	0	0	0			
Portable cement mixers	2	4	5	12		40	1,920	240	115,321	221,415,648	221,416	221.42	244.07	221,416	221	244			
Chute and Stilling Basin Emissions											6,511,284	6,511	7,177		2,350,598	2,351	2,591		
BORINGS FOR APPROACH CHANNEL COFFERDAM (4 months)									Late 2010 - Early 2011										
Diesel & Hydraulic drill rig	1	10	5	4		50	800	100	63,991	51,192,952	51,193	51.19	56.43	51,193	51	56			
Flat bed trucks	2	4	5	4					Off-site Haul Truck calculations										
Borings for Approach Channel Emissions											51,193	51	56		51,193	51	56		
TOTAL EMISSIONS											10,677,300.0	10,677.3	11,769.6						

Construction Equipment GHG Emission Rate (grams per hour) from Corps 2009

Equipment Type (2009)	Max HP	CO ₂	
Bore/Drill Rigs	175	63,991.19	Project will use 140 hp drills
Paving Equipment	250	55,470.42	
Rollers	120	26,756.84	
Cranes	250	50,874.43	
Crawler Tractors	750	210,778.38	
Crushing/Proc Equipment	750	267,090.67	
Rough Terrain Forklifts	500	116,378.69	
Rubber Tired Dozers	750	180,887.50	
Rubber Tired Loaders	750	220,232.06	
Excavators	500	106,020.60	
Graders	500	104,092.36	
Off-Highway Tractors/Compactors	750	257,699.59	
Scrapers	500	145,797.55	
Skid Steer Loaders	120	19,396.44	
Off-Highway Trucks/Water Trucks	1,000	283,370.04	
Other Construction Equipment	500	115,320.65	
Pavers	500	105,798.73	
Surfacing Equipment	750	157,418.36	
Tractors/Loaders/Backhoes	120	23,463.43	
Trenchers	500	141,207.16	
Emission factors for CO ₂ from (Corps 2009)			